INTRODUCING MODERN AGROFORESTRY TO STUDENTS AS THE NEXT GENERATION OF DECISION MAKERS IN ECOSYSTEM MANAGEMENT

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Abstract

Agroforestry (AF) in temperate climatic regions is often subject to ignorance or misunderstanding within the agricultural sector. The most obvious reason is a missing integration of temperate AF as a subject in the student's curricula of related disciplines. Here, we present an example from the University of Göttingen, Germany, where more than 250 students have joined a specific and interdisciplinary course on AF since the last years. As we continuously received a very positive feedback, we allow us to present some selected results, gained from the student´s work on an extra installed field site, composed as an alley cropping system with poplar and willow short rotation coppices strips on cropland. Overall, we are convinced that our multidisciplinary approach, combining lab and field works as well as producing first relatively simple but clear results with respect to the agroforestry issue could help to promote the agroforestry approach in the long run.

Keywords: temperate agroforestry, student's curricula, short rotation coppices, water budget, crop yields, mineral nitrogen

Introduction

Agroforestry (AF) in temperate climatic regions is often subject to ignorance or misunderstanding within administrative bodies and stakeholders of the agricultural sector. Here, AF is regularly linked to only the tropical- and sub-tropical scope or, for temperate areas, to only historical land use applications like e.g. "Streuobstwiesen". However, already since decades knowledge of various modern scientific or practical approaches in temperate AF is available, like for instance for the USA or France. To our understanding, the most obvious reason for such an ignorance in most other countries is a missing integration of temperate AF as a subject in the student's curricula of related disciplines like agriculture, forestry or geosciences.

Nevertheless, things might change: Since 2010, the University of Göttingen offers an interdisciplinary bachelor program on "Ecosystem Management" (www.uni-goettingen.de/en/84745.html). Three faculties contribute to this course, the faculty of agricultural sciences, the faculty of forest sciences and forest ecology and the faculty of geoscience and geography. Based on the insight into the essentials of agriculture, forestry and the geosciences, the key object of the degree course is to get to know the most important facts and concepts from ecology and economics and develop an understanding of the interaction of ecosystems. Within this study course, a specific module on agroforestry was incorporated (4 h present time per week, total work load of 180 h per semester, 6 study credit points). Furthermore, the module´s field experiments are also linked to the bachelor program "Molecular Ecosystem Sciences", focusing on the impact different land use types on biogeochemical processes (www.uni-goettingen.de/en/203287.html). So far, our seminar is the first and still only explicit study module on temperate AF in Germany.

The focus of the study module lies on self-collected, preferably self-measured, as well as scientifically evaluated and presented field data. For that, we installed an extra field site in autumn 2010, composed as an alley cropping system. Tree strips of poplar and willow short rotation coppices (SRC) were combined in a block design with a common crop rotation in the alleys (Figure 1). Field data are collected and evaluated with respect to the impact of the given system on the thematic issues of water cycling, nutrient and C budgets, crop production, and biological diversity. Students are working in groups of 3 to 6 persons in each summer semester, dealing with specific questions of the given thematic fields. e.g:

- How is the soil structure and the infiltration capacity influenced by the tree component?
- Is there any significant impact on crop yields?
- Is there any indication for changes in the mineral nitrogen availability in the tree strips?
- What is the reduction of PAR within and next to the tree strips?
- How is the management of the tree component done, and what is it's net benefit?
- How do earthworms react to the AF application?
- Do small mammals and the epigaeic fauna benefit from the integrated tree strips?

Until now, more than 250 students have joined the course, and as we continuously received a very positive feedback from our students, we allow us to present in the following some selected approaches and results, gained from the students' work on our educational field plots in the given context.

Figure 1: Field site installed in autumn 2010, composed as an alley cropping system.

Results

I) Soil structure, infiltration capacity and the water budget

Applied methods

- Soil texture analysis
- Creating a water retention curve
- Determining the saturated water conductivity
- Estimating the infiltration rate
- Approximating a water budget under given climatic conditions for various crops

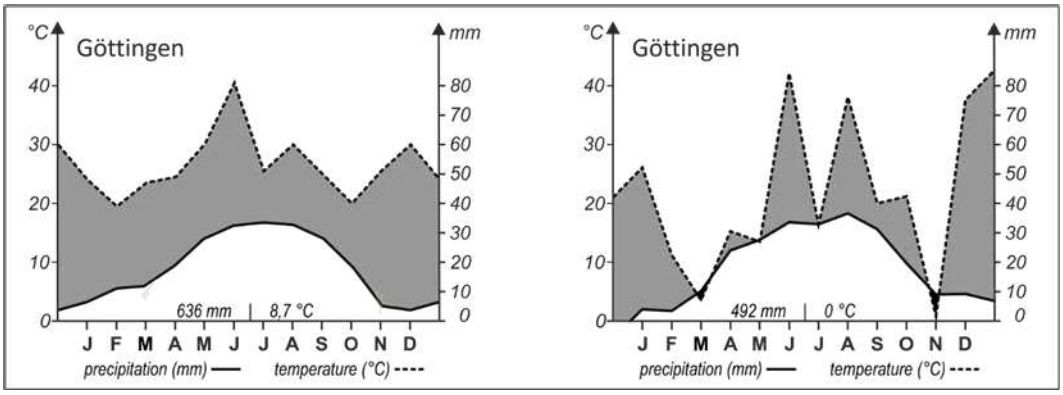

Figure 2: Long-term average (1961-1990) (left) and 2011 precipitation and temperature (right).

Selected results

- Due to the relative shallow soil layer, the study site is not suitable for every field crop. The water storage capacity is restricted for the cultivation of wheat, barley and sugar beet (Figure 3).
- On a long-term average, there is a positive water budged, i.e. a net seepage water output.
- In single years (here 2011) and certain critical growth periods (e.g. spring time) there is not enough plant-available water. Reduce growth or even drought stress might occur (Figure 2).
- Due to their intensive and deep-rooting, willow and poplar will i) gain water in such drought phases also from deeper soil layers but ii) might simultaneously reduce the seepage water output to zero then.

Conclusions on water issues

- When applying SRC within an agroforestry system, the water budged of the site has to be seriously considered.
- By deep-rooting, SRC as a tree component may help to gain water source from deeper soil layers. A hydraulic lift as well as the shadow of trees might help to protect the annual crops from drought stress.

Figure 3a: Liquid, gaseous and solid phases of the soil.

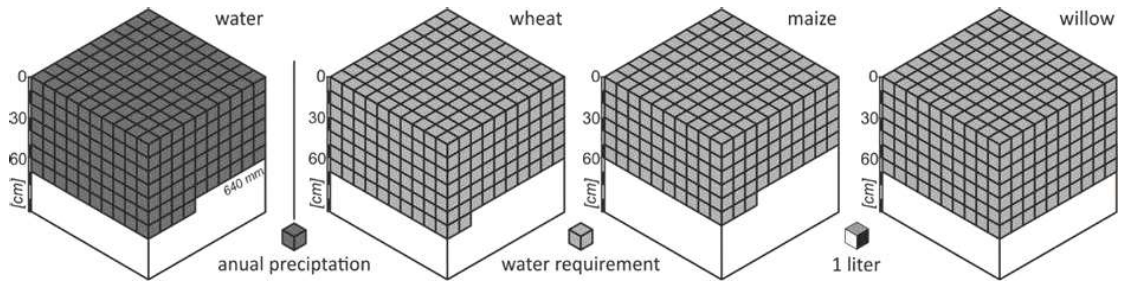

Figure 3b: Mean annual precipitation in Lower Saxony and crop-specific needs of water.

II) Crop yields

The aim of the research of the agronomy group of students is to assess the effect of alley cropping with short rotation coppice species on the yield formation of the annual agricultural crops. These crops change every year with winter wheat and canola as the main species in a crop rotation. The hypothesis is tested that the tree rows affect the growth conditions for the annual crops and therewith the morphology and biomass of the crop plants. A range of different measurements are performed in the crop in spring, at a time, when the crop species are flowering. It is assumed that at this stage the peak standing crop, i.e. the total above ground biomass is almost reached.

Applied methods

- Recording crop, weed and open soil covering by RGB imagery
- PAR measurements above the crop and at ground level
- LAI detection via calibrated spectrometry
- Identifying the tiller density, sward height, above ground biomass and leave/steam ratios (Figure 4)
- Soil water content
- ANOVA analysis via 'R', factors tree row (4 levels), slope/tree species (3 levels) and distance to the tree row (1.5 or 10 m).

Selected Results

- Over the years of measurements, the distance from the tree row has been proven to exert the strongest effect on the agricultural crop.
- Also the exposure showed some effects while the slope/tree species and the number of the tree row as well as the two- and threefold interactions were of minor importance.

Conclusions on crop yields

The Göttingen agroforestry experiment has been proven as a valuable resource for capacity building in the field of agronomy and crop growth in a sustainable production system.

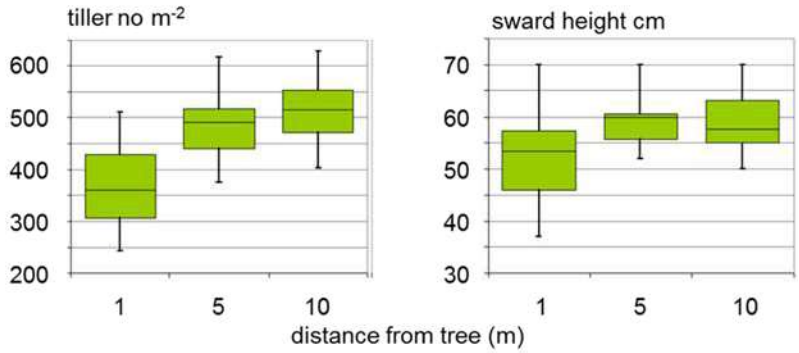

Figure 4: Tiller density (left) and sward height (right) of winter wheat at the flowering stage in relation to the distance from the tree row.

III) Mineral nitrogen availability and N_2O emissions

Applied methods

- Mineral N was detected after immediate *in situ* extraction with 0.5 M K_2SO_4 of samples from the upper 5 cm soil layer
- N_2O was measured in air samples of the headspace of gas chamber

Selected Results

- Results indicate significantly higher NO_3 but reduced NH_4 contents in the crop rows, compared to the trees rows
- N_2O emissions are significantly enhance in the crop rows while tree rows indicate a sink at the time of sampling (Figure 5)

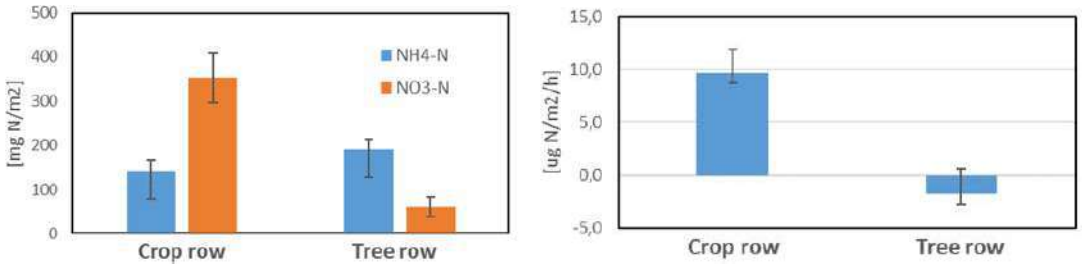

Figure 5: N_{min} (left; 0-5 cm soil depth) and N_2O emissions (right), n = 5 per plot, IX 2017.

Conclusions on nitrogen cycling

- Results indicate that tree rows of SRC on crop fields bear a significant potential to reduce NO_3 leaching as well to decrease N_2O emissions

IV) Educational implications

Overall, we are convinced that such a multidisciplinary seminar approach, combining lab and field works as well as producing first relatively simple but clear results with respect to the agroforestry issue could be a valuable example also for other universities and education units, which help to promote the agroforestry approach in the long run. It may thus be widening the students' perspective with regard to the issue "trees in agriculture", as well as improving their responsibility as the future generation of decision makers in landscape- and ecosystem management.